ISSN: 0976-9102 (ONLINE)
DOI: 10.21917/ijivp.2019.0300

ADAPTIVE MEAN DEVIATION BASED TRIMMED MEDIAN FILTER FOR THE REMOVAL OF HIGH DENSITY SALT AND PEPPER NOISE

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Abstract

This paper suggests an effective algorithm based on the average variance from the digital images to eliminate salt and pepper noise. The proposed algorithm chooses the 3×3 window to unsymmetrically decorate the corrupted pixel and to swap the corrupted pixel for the median of the other pixel. In the chosen pane, on the other side, the screen width will be decreased by two when the whole pixel comprises 0 and 255 and the same process will be replicated. When noisy pixel values cannot even be achieved in a 7×7 frame, then the main pixel will be substituted with a small statistical variance. Experimental results show that the algorithm suggested continuously operates to reduce noise from salt and pepper. The unbiased, analytical analysis of the proposed algorithm shows that the proposed algorithm beats the current state-of-the-art algorithm for noise reduction, such as SMF, AMF, DBA and MDBUTMF.

Keywords:

Adaptive Median Filter, Decision Based Algorithm, Mean Deviation and Standard Median Filter

1. INTRODUCTION

Impulse noise occurs during image acquisition, transmission and storage. The defined and impulse sound of the pulse is regarded as salt and pepper noise, along with a spontaneous beloved intermittent impulse. Such noisy pixels' trigger edge-like characteristics of image processing software, so they should be eliminated before storage. The human eye is also prone to distortion in the picture at high frequencies. In terms of pulse noise reduction and conservation of other picture data, the nonlinear filters have been used to increase the filters performance.

Various authors have recommended various nonlinear filters in this sense to eliminate salt and pepper noise. The median filter is used as the edge data in objects is retained. The filter also adjusts the noiseless pixel function so that it is only sufficient for very low noise level. This reveals the fluidity of wider windows at high noise level, and for smaller models it is unable to eliminate noise entirely.

Weighted median filter [7] and its variations have a certain degree of weight control over the smoothing behaviour. Contemporary filters split the process of image denoisation into two steps. The first phase is noise analysis, and the second step is noise pixel quality substitution with estimated value, where the average usually serves as the estimator. These are medium-weighted filters, adaptive impulses with weighted middle filters [6] and sorting algorithm for order ratings. At lower noise level is excellent the output of the center-weighted median filter, regular adaptive median filter [5] and progressive intermediate filter [14]. There are several noisy pixels that must be substituted at low noise level.

DBA [11] is proposed to overcome this disadvantage. This uses the average value or the median of the previously processed pixel for neighborhood noise reduction in an image. When a noise level is substituted by a calming image, the median value shall be 0 or 255. This adds to a deterioration.

MDBUTMF [3] is suggested to avoid the major disadvantage of DBA. The minimum value and maximum value as pepper signal and salt noise respectively in the dynamic range are taken up in this method for high noise intensity salt and pepper elimination.

If all the pixels in the 3×3 window are skewed, the main drawback will be the higher noise densities, which ensures the mean value for all components in the window will override the error variable, which is also a noise quality.

FSBMMF is given in [13], either a mid or median price based on the number of pixels that are free from noise in the window is substituted with a corrupted pixel. If the noise level is small, the algorithm fails.

The proposed adaptive mean deviation based trimmed median filter (AMDTMF) algorithm removes this drawback at high noise density and gives better Peak Signal-to-Noise Ratio (PSNR), Image Enhancement Factor (IEF) and Structural similarity index (SSIM) values than the existing algorithm

2. IMPULSE NOISE

Impulsive noise is a variety of causes, such as shifting interference, adverse channel conditions in the communication system, fall offs and surface loss of sound recordings, tapping on computer keyboards, and so on, which are relatively short period. An impulse noise filter can be used to increase the quality and intelligibility of noise signals and to gain robustness in the detection of models and adaptive systems. The median filter is the standard way to remove impulsive noise. The impulse filter however often contributes to a loss of the signal.

The impulsive sound originates in a communication system at some time in space, then travels to the receptor via the channel. The noise obtained is defined by the stream and can be considered as the response to the channel impulse. In general, linear or non-linear, stationary or time characteristics of communications channels may vary. In addition, many of the communication systems have a nonlinear characteristic in response to a large-amplitude impulse.

In the time domain rather than the frequency domain, the pulse interference is typically more recognizable and noticeable, and the time domain signal processing is ideal for noise reduction or deletion. The goal of signal detection and the parameter estimation can be to adjust a number of samples for the normal sound effects and, in some situations, to filter the impulsive noise within the frequency sector when the noise influence is a variation of the mean signal range.

3. PROPOSED FILTER

Initially, the algorithm senses the noise in the image. A static or noiseless method is taken to check the extracted pixels. The pixel is considered noisy when the processed pixel holds the gray level maximum and minimum. It is noise free if the price stays between the two gray points. The algorithm of the proposed work is as follows.

3.1 ALGORITHM

Step 1: Initialize the window size as 3×3 (maximum value of window is 7×7. If the window size exceeds 7×7 the image gets blurred). Assume that the pixel being processed is $c_{i,j}$.

Step 2: If 0< $c_{i,j}$<255 then $c_{i,j}$ is uncorrupted pixel and its values is left unchanged.

Step 3: If $c_{i,j}$ = 0 or $c_{i,j}$ = 255 then $c_{i,j}$ is corrupted pixel then two cases are possible as given in case (i) and case (ii).

Case (i): If the selected window contains all elements as 0's and 255's then increases the window size and go back to step 3.

Case (ii): If the selected window contains not all elements as 0s and 255s the eliminate 0s and 255s and find the median value of the remaining elements. Replace $c_{i,j}$ with the median value.

Step 4: If the 7*7 window contains all 0s and 255s or both, then replace the $c_{i,j}$ with the mean deviation parameter.

$$MDP = \frac{\sum\left|Z-\bar{Z}\right|}{N}$$

where, Z = element of the window, $\bar{Z}$ = mean of the window element and N = total number of element

Step 5: Repeat steps 1to 4 until all the pixels in the entire image are processed.

4. SIMULATION AND EXPERIMENTAL RESULTS

The performance of the proposed algorithm is tested with different gray scale images of size 512×512 such as Lena, Pepper, baboon and Bridge. Standard median filter (SMF), Progressive switching median filter (PSMF), Adaptive median filters (AMF), Decision based algorithm (DBA), Modified decision based unsymmetric trimmed median filter (MDBUTMF) and Fast switching based are used for comparison.

The proposed and other existing filters are used for comparison are implemented in MATLAB R2013a on a PC equipped with 2.16GHz CPU and 4GB RAM memory for the evaluation. The performance is based on the noise density value that varies between 10% and 90%. Denoising performances are quantitatively measured by PSNR, IEF, SSIM and MAE defined in Eq.(1) to Eq.(5) respectively.

$$PSNR\left(dB\right)=10\log_{10}\left(\frac{255^2}{MSE}\right) \tag{1}$$

$$MSE=\frac{\sum\sum\left(Y\left(i,j\right)-\bar{Y}\left(i,j\right)\right)^2}{M\times N} \tag{2}$$

$$IEF=\frac{\sum\sum\left(\eta\left(i,j\right)-Y\left(i,j\right)\right)^2}{\sum\sum\left(\bar{Y}\left(i,j\right)-Y\left(i,j\right)\right)^2} \tag{3}$$

$$SSIM\left(x,y\right)=\frac{\left(2\mu_x\mu_y+c_1\right)\left(2\sigma_{xy}+c_2\right)}{\left(\mu_x^2+\mu_y^2+c_1\right)\left(\sigma_x^2+\sigma_y^2+c_2\right)} \tag{4}$$

$$MAE=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|Y\left(i,j\right)-\bar{Y}\left(i,j\right)\right| \tag{5}$$

where PSNR stands for peak signal to noise ratio, MSE stands for mean square error, IEF stands for image enhancement factor, SSIM stands for Structural similarity Index and MAE stands for Mean absolute error. $M\times N$ is the size of the image, $\bar{Y}$ denotes denoised image, Y denotes the original image and η denotes the noisy image. μ_x is the average of x, μ_y is the average of y, σ_x^2 is the variance of x, σ_y^2 is the variance of y, σ_x^y the covariance of x and y.

The PSNR, IEF, SSIM and IEF values of the proposed algorithm are compared against the other existing algorithms by varying the noise density from 10% to 90% are shown in Table.1 to Table.4. From the Table.1 to Table.4, it is seen that the proposed algorithm demonstrates better PSNR, IEF, SSIM and IEF improvement compared to the existing algorithms irrespective of noise densities. A plot of PSNR, IEF, SSIM and MAE against noise densities for Lena image is shown in Fig.1 to Fig.4 respectively.

The PSNR values of different images using different algorithms are shown in Table.1. From the table, it is seen that the proposed algorithm demonstrates better PSNR values irrespective of the nature of the input image.

Table.1. Comparison of PSNR values of different algorithms for Lena image at different noise densities

ND (%)	PSNR in dB						
	SMF	AMF	PSMF	DBA	MDBUTMF	FSBMMF	PA
10	33.25	34.43	36.82	36.4	37.91	39.57	43.04
20	28.91	30.4	32.40	32.9	34.78	35.12	39.75
30	23.63	28.11	28.94	30.15	32.29	32.02	36.91
40	18.98	24.4	24.97	28.49	30.32	31.48	35.03
50	15.29	23.36	20.48	26.41	28.18	30.23	33.18
60	12.36	20.6	12.26	24.83	26.43	28.71	31.37
70	9.97	15.25	9.95	22.64	24.3	27.36	29.16
80	8.17	12.31	8.09	20.32	21.7	25.67	26.49
90	6.68	10.93	6.65	17.14	18.4	22.68	23.28

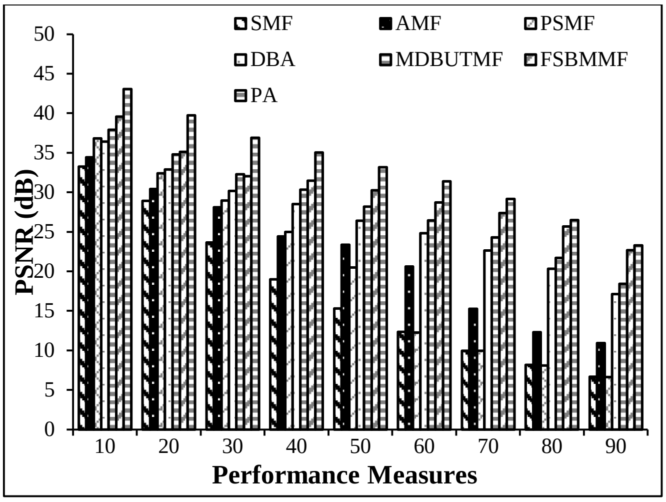

Fig.1. Comparison of PSNR values of different algorithms for Lena image at different noise densities

Table.2. Comparison of IEF values of different algorithms for Lena image at different noise densities

ND (%)	IEF						
	SMF	AMF	PSMF	DBA	MDBUTMF	FSBMMF	PA
10	10.36	199.78	171.63	390.67	590.53	592.69	598.46
20	28.17	235.72	207.31	358.91	480.74	500.76	540.90
30	30.02	226.39	190.92	322.89	420.46	421.39	423.23
40	23.12	181.82	143.49	268.49	351.98	354.81	362.86
50	11.72	151.88	62.98	208.77	240.39	270.74	300.35
60	6.73	129.06	6.61	58.89	138.39	160.87	241.37
70	3.31	98.37	3.28	49.60	63.60	129.19	164.55
80	2.00	68.74	1.98	35.69	25.91	98.47	100.50
90	1.37	15.53	1.37	19.70	10.73	40.68	59.89

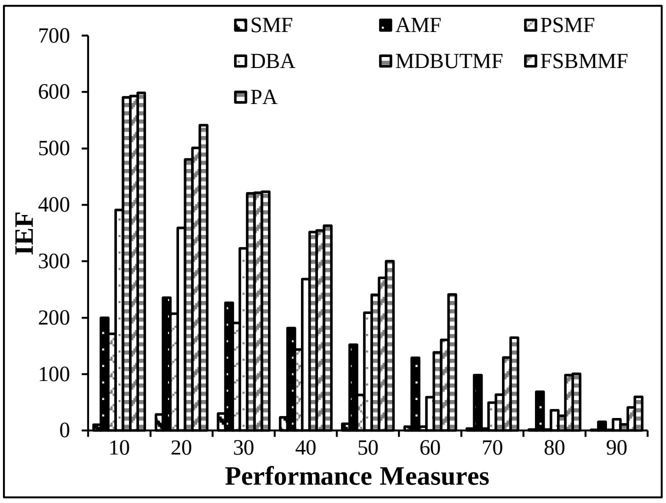

Fig.2. Comparison of IEF values of different algorithms for Lena image at different noise densities

Table.3. Comparison of SSIM values of different algorithms for Lena image at different noise densities

ND (%)	SSIM						
	SMF	AMF	PSMF	DBA	MDBUTMF	FSBMMF	PA
10	0.96	0.97	0.93	0.95	0.99	0.99	0.99
20	0.91	0.96	0.91	0.94	0.98	0.98	0.99
30	0.75	0.95	0.90	0.92	0.97	0.97	0.98
40	0.47	0.93	0.89	0.90	0.95	0.95	0.97
50	0.25	0.91	0.86	0.87	0.92	0.92	0.96
60	0.11	0.87	0.84	0. 82	0.84	0.86	0.94
70	0.05	0.83	0.74	0.78	0.67	0.81	0.91
80	0.02	0.75	0.43	0.69	0.61	0.77	0.85
90	0.01	0.53	0.11	0.45	0.54	0.69	0.75

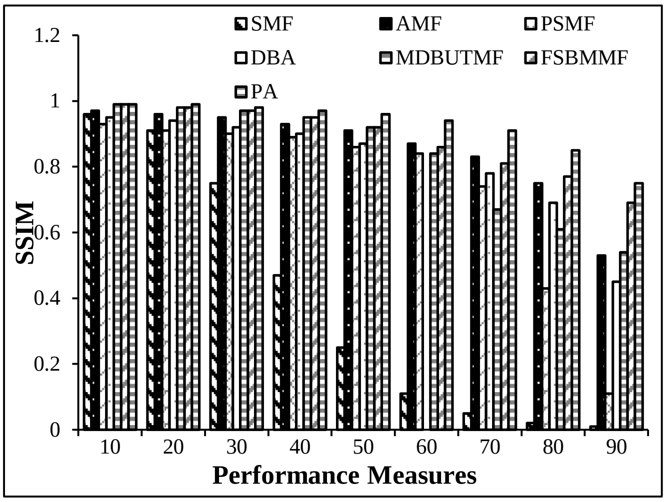

Fig.3. Comparison of SSIM values of different algorithms for Lena image at different noise densities

Table.4. Comparison of MAE values of different algorithms for Lena image at different noise densities

ND (%)	MAE						
	SMF	AMF	PSMF	DBA	MDBUTMF	FSBMMF	PA
10	1.77	0.72	0.83	0.40	0.29	0.44	0.29
20	2.50	1.07	1.50	0.89	0.64	0.94	0.64
30	4.27	1.53	2.10	1.49	1.05	1.58	1.055
40	8.38	2.11	2.83	2.16	1.51	2.25	1.49
50	15.80	2.79	3.65	3.04	2.11	2.29	2.03
60	28.43	3.71	4.56	3.94	3.11	3.88	2.70
70	46.46	4.79	7.39	5.45	5.09	4.81	3.64
80	70.42	6.60	21.58	7.40	8.54	6.23	5.32
90	97.25	13.46	66.74	11.74	10.35	9.45	8.679

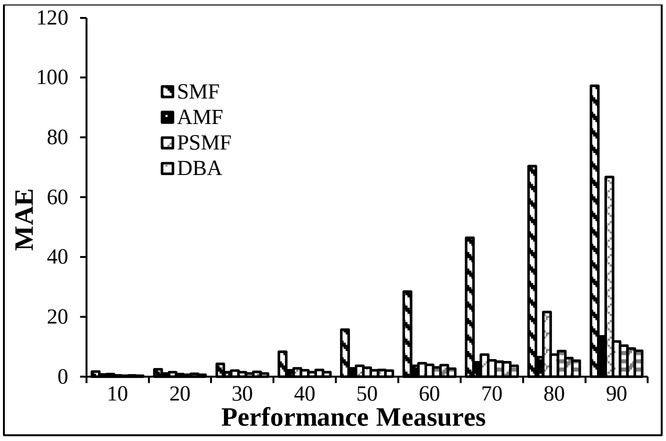

Fig.4. Comparison of MAE values of different algorithms for Lena image at different noise densities

In order to demonstrate the visual enhancement of proposed algorithm, another experiment is conducted on Lena image with noise density of 90%. The visual enhancement AMDTMF algorithm is compared with various existing techniques such as Standard median filter (SMF), Progressive switching median filter (PSMF), Adaptive median filter (AMF), Decision based algorithm (DBA), Modified decision based unsymmetric trimmed median filter (MDBUTMF) and Fast switching based mean median filter(FSBMMF). Visual enhancement of denoised. Lena image with noise density of 90% is shown in Fig.5. It is clear from Fig.5 that the image recovered from the AMDTMF algorithm is better than other noise removal algorithms in terms of visibility.

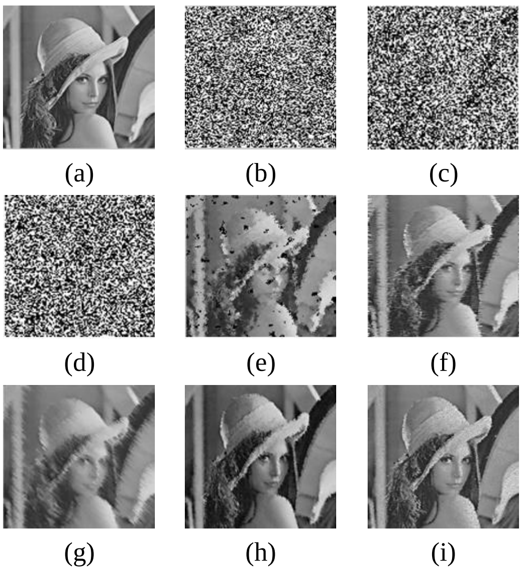

Fig.5. Results of different filters in restoring 90% corrupted image Lena (a) Input image (b) Noisy image (c) Simple Median filter (d) PSMF (e) AMF (f) DBA (g) MDBUTMF (h) FSBMMF (i) Proposed filter

5. CONCLUSION

In this paper, a new algorithm is proposed which gives better performance in comparison with SMF, AMF, PSMF, DBA, MDBUTMF and other existing noise removal algorithms in terms of PSNR, IEF, SSIM and MAE. The performance of the algorithm has been tested at low, median and high noise densities on gray scale images. Even at high noise density levels the proposed filter gives better results in comparison with other existing algorithms. Both visual and quantitative results are demonstrated. The proposed algorithm is effective for salt and pepper noise removal in images at high noise densities.

REFERENCES

[1] J. Astola and P. Kuosmaneen, "*Fundamentals of Nonlinear Digital Filtering*", CRC Press, 1997

[2] J.B. Bednar and T.L. Watt, "Alpha-Trimmed means and their Relationship to Median Filter", *IEEE Transactions on Acoustics, Speech, Signal Processing*, Vol. 32, No. 1, pp. 145-153, 1984.

[3] S. Esakkirajan, T. Veerakumar, Adabala N. Subramanyam and C.H. PremChand, "Removal of High Density Salt and Pepper Noise Through Modified Decision Based Unsymmetric Trimmed Median Filter", *IEEE Signal Processing Letters*, Vol. 18, No. 5, pp. 287-290, 2011.

[4] R.C. Gonzalez and R.E. Woods, "*Digital Image Processing*", Prentice-Hall, 2002.

[5] Haidi Ibrahim and Nicholas Sia Pik Kong, "Simple Adaptive Median Filter for the Removal of Impulse Noise from Highly Corrupted Images" , *IEEE Signal Processing Letters*, Vol. 54, No. 4, pp. 1920-1927, 2008.

[6] H. Hwang and R.A. Hadded, "Adaptive Median Filters: New Algorithm and Results", *IEEE Transactions on Image Processing*, Vol. 4, No. 4, pp. 499-502, 1995.

[7] S.J. Ko and Y.H. Lee, "Center-Weighted Median Filters and Their Applications to Image Enhancement", *IEEE Transactions on Circuits and Systems*, Vol. 38, No. 9, pp. 984-992, 1991.

[8] W. Luo and D. Dang, "A New Directional Weighted Median Filter for Removal of Random-Valued Impulse Noise", *IEEE Signal Processing Letters*, Vol. 14, No. 3, pp. 193-196, 2007.

[9] W. Luo and D. Dang, "An Efficient Method for the Removal of Impulse Noise", *Proceedings of IEEE International Conference on Image Processing*, pp. 2601-2604, 2006.

[10] Shuqun Zhang and Mohammad A. Karim, "A New Impulse Detector for Switching Median Filters", *IEEE Signal Processing Letters*, Vol. 9, No. 11, pp. 360-363, 2002.

[11] K.S. Srinivasan and D. Ebenezer, "A New Fast and Efficient Decision-Based Algorithm for Removal of High-Density Impulse Noises", *IEEE Signal Processing Letters*, Vol. 14, No. 3, pp. 189-192, 2007.

[12] Stephen Gorard, "Revisiting A 90-Year-Old Debate: The Advantages of the Mean Deviation", *British Journal of Educational Studies*, Vol. 53, No. 4, pp. 417-430, 2005.

[13] V.R. Vijayakumar, G. Santhanamari and D. Ebenezer, "Fast Switching Based Median-Mean Filter for High Density Salt and Pepper Noise Removal", *International Journal of Electronics and Communication*, Vol. 68, No. 2, pp. 1145-1155, 2014.

[14] Z. Wang and D. Zhang, "Progressive Switching Median Filter for the Removal of Impulse Noise from Highly Corrupted Images", *IEEE Transactions on Circuits System II: Analog and Digital Signal Processing*, Vol. 46, No. 1, pp. 78-80, 1999.